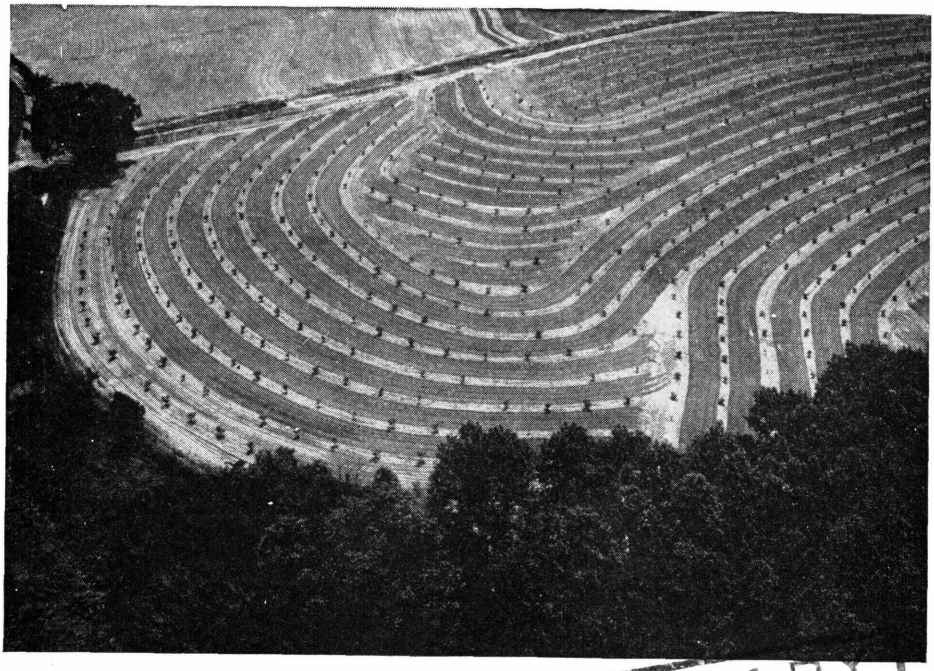
CONSERVING SOIL and MOISTURE in ORCHARDS and VINEYARDS



★

Farmers' Bulletin No. 1970
U. S. DEPARTMENT OF AGRICULTURE

FRUIT GROWN on farm lands of the United States contributes greatly to human enjoyment and human nutrition in our own country and in many others. At this time of world hunger, bountiful yields from our orchards and vineyards are needed more than ever. Fruit trees are acutely affected in their growth and yield by conditions of soil and slope. A fruit grower who has a favorable site can far outproduce one who practices the same methods with the same skill and industry on a site that is not particularly fitted for the purpose. Favorable fruit sites, like favorable sites for dam construction, are limited in number. It is therefore of the utmost importance that such sites be maintained in the highest possible state of productivity for the greatest possible number of years. This bulletin outlines practices by which fruit growers can take full advantage of site resources and prolong the productivity of their orchards and vineyards.

Washington, D. C. Issued September 1945

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 10 cents

CONSERVING SOIL AND MOISTURE IN ORCHARDS AND VINEYARDS

By JOHN T. BREGGER, *senior soil conservationist, Erosion Control Practices Division, and* GROVER F. BROWN, *principal agronomist, Agronomy Division, Soil Conservation Service*

Contents

INTRODUCTION

EROSION OF FARM LAND is found at its worst in improperly managed orchards and vineyards. This is explained chiefly by the fact that few cultivated crops other than fruits and nuts are grown continuously on the same land for so many years. Very commonly, orchard tree rows have been laid out incorrectly and the sites have been subjected to intensive cultivation up and down the slope throughout the life of the trees. Introduction of power farming has speeded up the destructive erosion of orchard and vineyard soils, by making it easy to cultivate intensively.

Another reason for the severity of soil erosion on orchard and vineyard sites is the almost universal choice of sloping land for such sites (figs. 1 and 2). Fruit plantings are made on sloping sites because the trees need good water drainage and good air drainage. Also, fruit trees and grapevines can be grown successfully on slopes too steep to be used satisfactorily for growing cultivated row crops and grains. In some parts of the country orchards are commonly established on valley slopes and river bluffs, sites that are often subject to severe erosion.

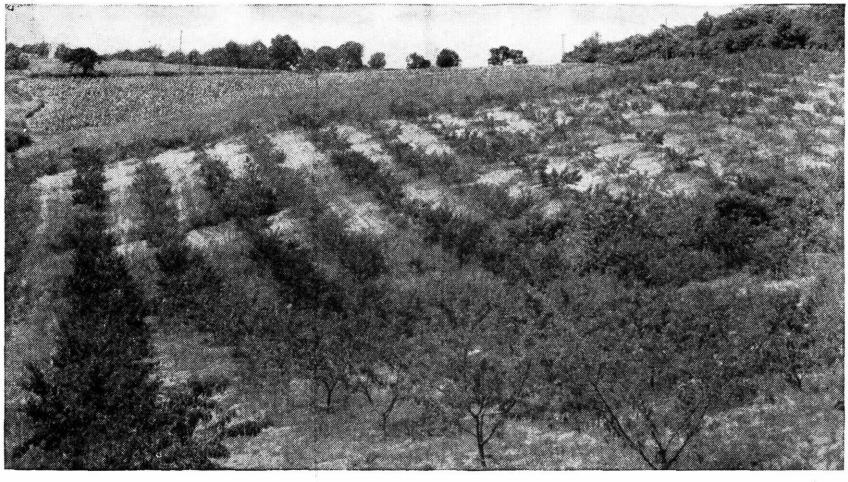


FIGURE 1.—Runoff and soil losses are most serious in a square-planted peach orchard on a long slope, cultivated up and down the hill. The trees are short-lived, and the site is left unfit for future orchard use.

Many of the best sites used by yesterday's generation of fruit growers are being ruined or have already been ruined for fruit production. For its future development, the fruit- and nut-growing industry depends largely on the preservation and proper use of a limited number of favorable sites.

A conservation program of orchard soil management is designed to bring about absorption by the soil of the greatest possible quantity of rainfall, prevent abnormal runoff, and hold soil losses to a minimum, and at the same time provide the cultural conditions most favorable to growth and fruiting of the trees—

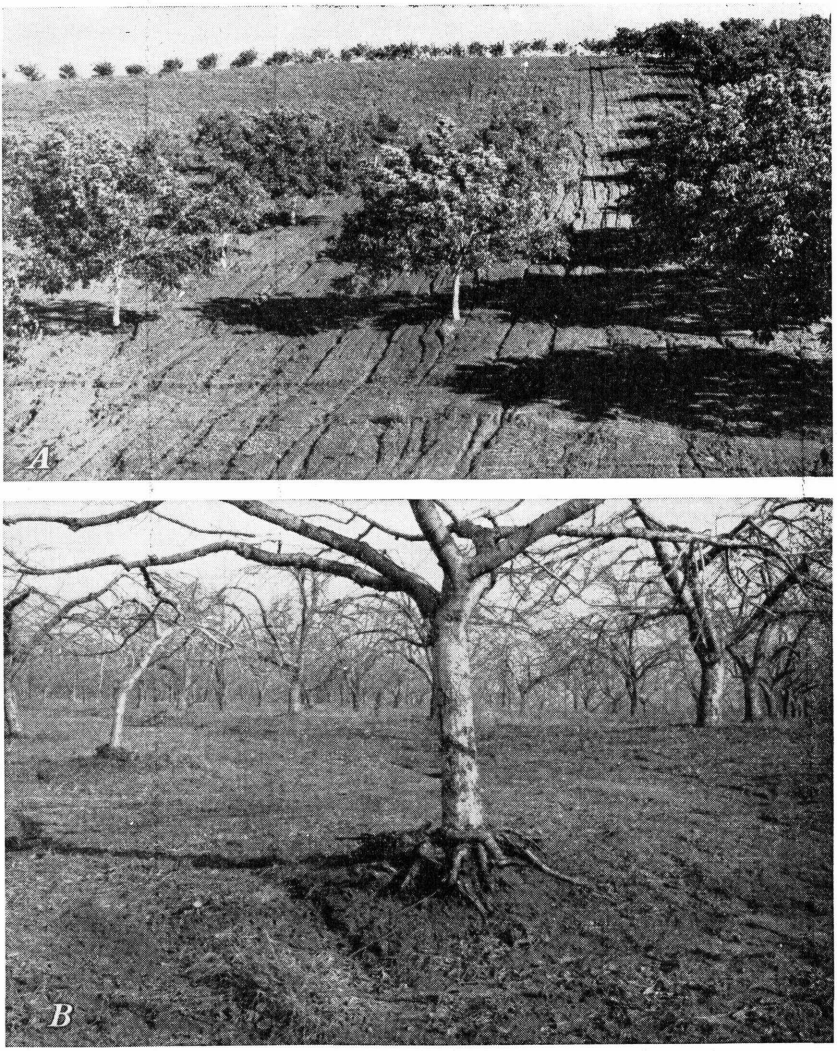


FIGURE 2.—*A*, In this steeply sloping walnut orchard, severe soil losses took place after a summer period of intensive cultivation, before the annual winter cover crop became well established; *B*, although this cultivated orchard area slopes only gently, sheet erosion has exposed tree roots, decreased the rooting zone, and caused a deficiency of plant nutrients.

for example, conditions preventing undue wetness of orchard soil at any season. Contour planting should be adopted wherever it is practical, that is, wherever runoff occurs and surface relief is not too irregular to permit it. Contour planting is the necessary basis for terracing and contour tillage operations (fig. 3). Terracing conserves rainfall and soil and also provides for safe drainage of excess surface water. Other conservation measures usually needed for adequate erosion control are growing ground-cover crops and applying mulches, the purposes of which include protecting the ground surface, preventing leaching, and supplying organic matter for incorporation into the soil.

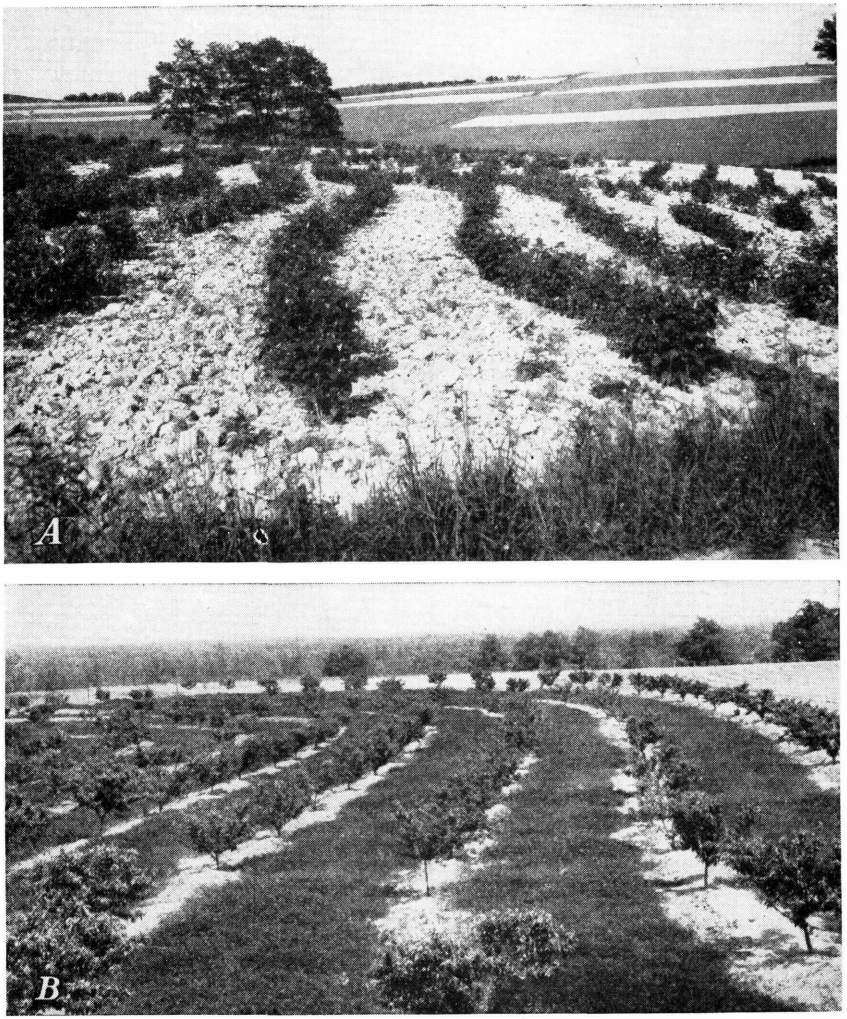


FIGURE 3.—*A*, These raspberry brambles, planted on the true contour, have given high yields; *B*, rapid tree growth has resulted here from terracing, contour cultivation, and use of winter leguminous cover crops.

CONTOUR PLANTING

In common agricultural use, "contour planting" means planting either on a true contour line (that is, a perfectly level line) or on a line having a grade along which water can move readily but cannot carry soil. Planting on contour lines is the first requirement for conservation management of orchard sites.

In laying out contour rows on an unterraced orchard site, the first step is to decide upon the minimum allowable interval between rows. Minimum interval between rows varies among different kinds and varieties of fruit trees. For example, it is usually 15 to 18 feet for peach trees, 25 to 30 feet for apple trees. It differs also with site conditions and according to individual preferences of fruit growers. The next step is to establish a point for location of the first contour line, the line at the highest elevation. From this location point the line is projected on the contour in both directions, by use of an engineer's level and rod, to the limits of the area to be planted. It is marked either with stakes or by making a furrow with a plow or other implement. A point for location of the second line is then established at the minimum interval from the first line, at the place where the slope downward from the first line is steepest, and this point likewise is projected on the contour in both directions. This procedure is repeated until the lower limit of the site is reached, each interval measurement being made at the point of steepest slope from the line just laid out. Wherever the distance between two adjacent lines becomes twice the minimum interval, a new line is laid out on the contour between them. Use of an engineer's level and rod makes it possible to lay out the contour lines either on the level or on any designated grade. Direction of grade depends on the location most suitable for the disposal of runoff water. This usually means running the grade to a natural draw or to an adjacent field or woodland in permanent cover.

The procedure described is illustrated by figure 4.

The average interval between contour rows of trees is in general somewhat greater than that between rows of trees planted on the square. It is desirable, therefore, that the average space between trees within a contour row be less than the average space between the rows, in order that the number of trees per acre may not be significantly less than if the planting had been done on the square. Where the space between contour rows is less than average the trees are usually set farther apart within the row.

Distance between trees in contour rows may be uniform or variable. In the direction perpendicular to the contours the trees may be either staggered or in line, according to variation in the interval between contour rows and to the individual grower's preference. Lining up the trees across the contour is sometimes preferred because of appearance and convenience, and because of the possibility that it will result in better air drainage.

Under a contour system of planting, orchard roads are placed where they will be least likely to receive and carry runoff water. Such locations include not only the natural ridges but, on a terraced site, the tree-row middles just below the larger terraces. Tree rows at these locations are spaced more widely to allow the necessary room for orchard trucks.

An important byproduct of contour orchard planting is more economical operation of orchard machinery. For either horse or tractor operations, maximum power requirement and rate of wear are significantly less when the operations are conducted on the contour rather than up and down the slope. Greater ease of operating machinery is especially important to the fruit grower when he is making an effort to meet the spray schedule in early spring, or in any other period when the ground is soft.

TERRACING[1]

With contour planting and tillage, all furrow ridges of soil become barriers to direct downhill flow of water. In common practice any contour structure of sufficient size or capacity to hold the runoff from the interval above it, within a certain margin of expected rainfall, and prevent downhill movement of this water may be called a terrace. Most terraces serve also as drainage channels to conduct excess surface water from the site at a velocity too low to cause soil loss, while offering a minimum of interference with machinery operations. Orchard terraces (figs. 3, *B*, and 4) are normally smaller and more closely spaced than terraces in a general-crop field. Extensive construction usually costs about the same on an acreage basis, although running the orchard terrace lines requires somewhat more time. A small additional expense is amply justified by the greater longevity of

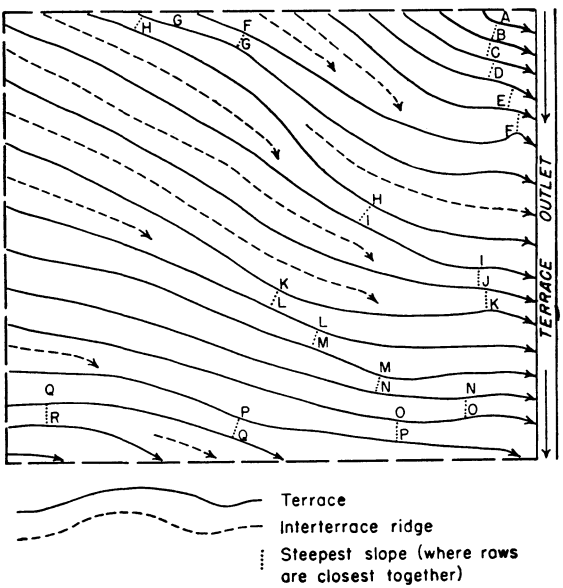


FIGURE 4.—Lay-out for terracing and planting an orchard area of rolling topography. Points A, B, C, etc., were established on the steepest slopes, at the interval selected as the minimum allowable distance between tree rows. Each point was then projected along the contour, in both directions, with an engineer's level. Terrace channels will be constructed at the lines thus established, and a row of trees will be planted on each terrace ridge. Wherever the distance between two adjacent through lines became twice the minimum interval, a "spur" line was similarly laid out.

[1] For detailed information on field terracing, see U. S. Dept. Agr. Farmers' Bul. 1789, Terracing for Soil and Water Conservation.

the orchard planting. Sites having standard field terraces in standard spacing also are desirable for orchard use.

All orchard terraces intercept runoff, but some are designed to discharge this water and some to retain it, according to local requirements. From the functional standpoint the terraces may usually be classified as of either the diversion type, which has one or more outlets and discharges water, or the absorption type, which is level and retains water until it is absorbed by the soil. Bench terraces (fig. 5), commonly used on an area having a

FIGURE 5.—Bench terraces, each consisting of a cultivated bench and a noncultivated riser, make it possible to grow oranges on this steep slope without soil loss.

general slope greater than 10 percent, have a very steep down slope, called a "riser," below the outer edge. The riser, because it cannot be cultivated, is invariably maintained in plant cover. Bench terraces may be of either of the two functional types.

Orchard terraces should be constructed from the upper side, in order to keep the slope below the terrace ridge from being any steeper than is absolutely necessary. In terracing shallow soils, caution should be exercised to avoid exposing too much subsoil.

As a result of recent studies and observations, planting of fruit trees on the ridge tops of orchard terraces is recommended. The "top of ridge" location offers several advantages, which vary according to local conditions. Greater topsoil accumulation and better soil aeration in wet seasons favor maximum root extension, which in turn promotes rapid top growth and early fruit production. In young cultivated orchards, the terrace ridge is more easily maintained at its original height because the trees are present to protect it. In older orchards, it offers an ideal location for a permanent buffer strip of vegetation, while allowing convenient passage of orchard machinery and trucks either in or above the terrace channel.

Terraces should be built long enough ahead of tree planting so

that the soil will become well settled before the trees are set out, especially in the case of light sandy soils. Root elongation of trees planted on the terrace ridges in fall or early spring will then take place rapidly enough for utilization of soil moisture from the terrace channel during the first growing season.

Many orchards are being planted on land that was previously terraced for field crops. On such sites additional small terraces or plow-built contour ridges, or both, should be provided between the original terraces (figs. 6, 7, and 8, *A*). In the course of time the smaller ridges can be enlarged into medium-sized terraces through contour cultivation and terrace maintenance operations. The narrowest space between each two adjacent field terraces is divided according to minimum row interval. Next, lines are projected in both directions from the points thus established, each line paralleling the terrace below where the contour lines diverge and the terrace above where the contour lines converge toward an outlet. This results in continuous drainage on all through rows.

In terracing a new site for orchard planting, it is usually advisable to build a terrace for each through tree row (figs. 3, *B*, 4, and 8, *B*). The chief advantages of this are that more trees have a terrace-ridge location and the water supply is more evenly distributed among the whole number of trees in the orchard. Lines for the terrace system are laid out by the method already described under the heading "Contour Planting." For part rows the usual practice is to prepare plow-built ridges that are either

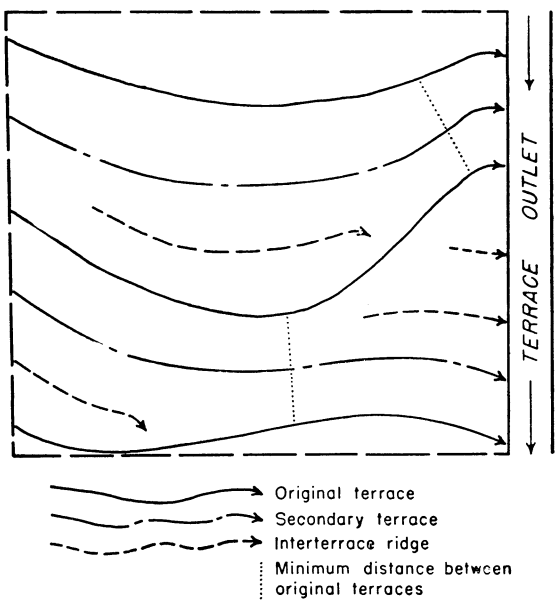


FIGURE 6.—Lay-out for adapting a field-terraced area to orchard use. Additional terrace and interterrace ridges have been established between original terrace ridges in such a way that all tree rows can be located on ridges and have continuous drainage toward the terrace outlet. Surplus water from part rows will drain either directly into the outlet or into the terrace channel below.

level or on a slight grade, and that drain into the terrace channel below at one or both ends.

Terrace maintenance is as necessary as correct terrace construction. In orchards where some annual cultivation is required, a tillage operation and a terrace maintenance operation become as one if suitable orchard equipment is used. Otherwise one or two additional operations per year may be required for terrace maintenance, that is, for maintaining the channel at full capacity and keeping the ridge at its original height. The desired results can be obtained with a single-disk harrow, an offset disk harrow, a disk tiller, a plow-and-V-drag combination, or a small unmounted blade of the Martin ditcher type. As the orchard trees become larger and the terraces broader, each channel eventually may occupy the greater part of a row middle.

TERRACE OUTLETS

Terrace outlets (fig. 4), wherever possible, should be natural drainageways. In the absence of a suitable waterway, it is necessary to construct an outlet. Extreme care should be exercised to determine the extent of the tributary area and make the outlet large enough for all the water likely to flow into it. Otherwise, severe damage may result. The water may cut through the protective vegetation at the bottom of the outlet, causing a deep gully, or may overflow and thus cause erosion damage on adjoining lands. The outlet should be prepared for and provided with a plant cover well in advance of turning in water.

Establishing a good plant cover in a prepared outlet is especially difficult, because of abnormal soil and moisture conditions. A firm, well-prepared seedbed is the first essential to establishing a successful stand of small-seeded grasses or legumes. This may

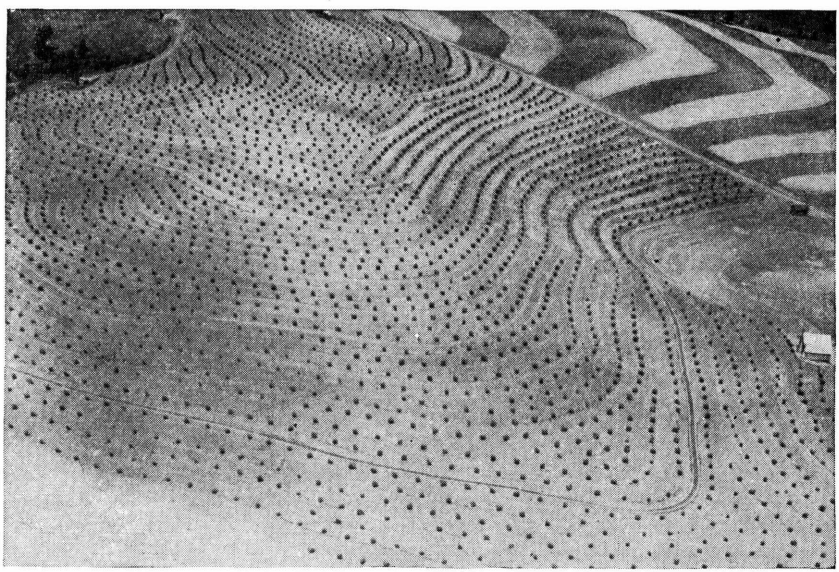


FIGURE 7.—Field-terraced land used for peach orchard in which interterrace rows are planted on contour ridges. Orchard roads are seen below some of the large through terraces.

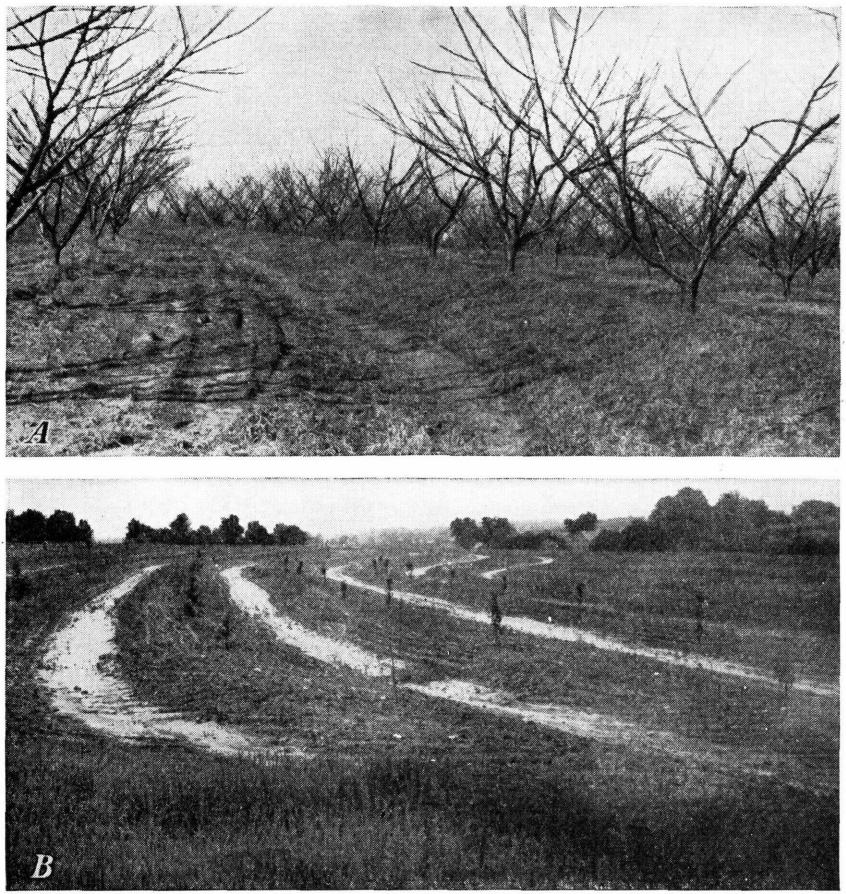


FIGURE 8.—*A*, On this field-terraced orchard site, trees have been planted on terrace ridges and smaller contour ridges, illustrated at right and left, respectively; *B*, here a terrace for each through tree row affords protection from surplus surface water and maximum conservation of moisture.

call for different equipment than is found on most fruit farms in the line of disks, packers, and seed drills. A cultipacker or similar implement should be used to firm the soil before seeding. If a drill is not available, seed may be broadcast either by hand or with a broadcast seeder and covered very lightly by running the cultipacker over the land again. Where conditions permit use of a small seed drill, a better job of planting most small-seeded grasses and legumes is possible than can be done by broadcasting. In general, a more liberal plan of fertilizing and liming should be followed than in seeding perennial hay and pasture mixtures on soils of equal fertility. Cost of lime and fertilizer is more than justified by thick stands of grasses and legumes.[2]

Sod-forming grasses are most suitable as a plant cover for terrace outlets, particularly because of their capacity to heal any scarred area quickly. Because of their fibrous root systems they

[2] For a more detailed discussion of methods of establishing a plant cover in an outlet, see U. S. Dept. Agr. Farmers' Bul. No. 1814, Terrace Outlets and Farm Drainageways.

give very good protection to the surface soil, and because of their low habit of growth they offer minimum resistance to the flow of water. Under the climatic conditions to which it is adapted, kudzu offers excellent protection for steep or deep outlets where soil conditions are unfavorable to the sod-forming grasses.

Plant cover in a terrace outlet should be carefully maintained and protected against damage by equipment. Otherwise very serious gullying may result.

FIGURE 9.—This newly constructed orchard diversion has ample water-carrying capacity but, when a suitable plant cover has become established, can easily be crossed by farm machinery without damage.

DIVERSIONS[3]

Diversions (diversion ditches) are structures that have greater carrying capacity than terraces and are designed exclusively to intercept water and carry it directly to stabilized areas (fig. 9). They should have ample channel capacity for carrying flash runoff of unusual volume without danger to land below. They are kept permanently in vegetation of a type that offers maximum protection against scouring but obstructs the flow of water as little as possible. Cultivation of diversions, by destroying the sod, would destroy their usefulness and increase the danger of abnormal erosion. In some cases a grass-legume hay type of vegetation can be used for the entire area occupied by a diversion. Such an area is sometimes of a size that justifies mowing its vegetation, in which case the mown material becomes available for use as orchard mulch.

Diversions may be constructed within noncontour orchards to intercept runoff on long slopes, thus preventing concentration that would result in severe gullying. They should be so designed that they can be crossed easily by machinery, especially where up-and-down-slope crossings are necessary. Where an orchard road

[3] For specific technical information regarding construction of diversions, a fruit or nut grower should apply to his soil conservation district office, a representative of the Soil Conservation Service, the State agricultural extension service, or the State agricultural experiment station.

crosses a diversion, the channel should be amply wide and the ridge should be reinforced with rocks.

An orchard situated part-way down a long slope sometimes receives considerable quantities of runoff from land nearer the top. Diversions are useful for intercepting such runoff before it reaches the orchard. In constructing diversions for this purpose, care should be taken to make them large enough. In some situations a diversion is needed to control water that otherwise would flow into an orchard from a highway.

Outlets for diversions should be established and managed in the same manner as outlets for terraces. In some cases, runoff carried by diversions can be impounded in farm ponds or reservoirs, where it becomes available for uses such as spraying.

SOD WATERWAYS

All waterways, or natural drainageways for surface water, should be kept in sod (fig. 10). These drainageways are especially necessary to prevent gullying in a nonterraced orchard where the runoff pattern results in water concentration. In a terraced orchard, terraces may drain into several sod waterways within the orchard instead of directly into a single outlet.

Sod waterways carrying excess surface water from the orchard merit careful attention to prevent them from becoming gullies. They should be maintained at ample width and should be limed and fertilized sufficiently to maintain a dense plant cover at the ground surface. All cultural equipment should be raised or straightened when being moved across them, to prevent damaging the sod. The vegetative cover on large waterways can be mowed for mulch or other uses.

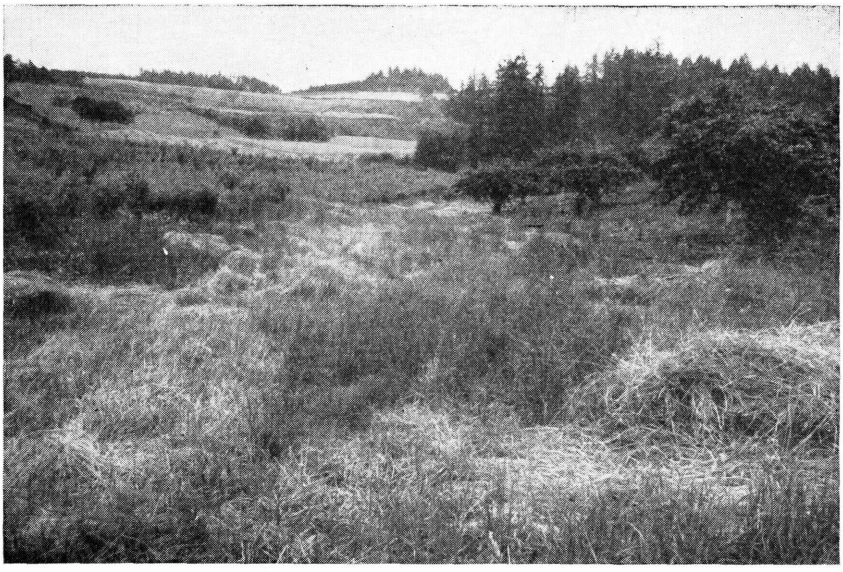


FIGURE 10.—Natural waterways on sloping orchard sites should be maintained in sod.

MULCH

"Mulch" here refers to any type of loose organic material covering the surface of the soil. The quantity of material that makes an effective mulch ranges between the amount that will just cover the soil surface and a layer adequate to smother all weeds.

Various materials are suitable for use as mulch. A mulch having a ligneous (woody) texture resists decomposition longer than one having a higher protein content, such as alfalfa hay, and therefore requires less frequent replacement. Grain straw, hay, corn stalks, and many wild native grasses are excellent mulching materials. Individual choice among the different materials depends largely upon availability and cost. Many a fruit grower produces his own supply of orchard mulch on parts of his farm not used for fruit production.

An orchard mulch serves primarily the functions of conserving moisture and controlling erosion (fig. 11). Its effectiveness increases with depth and with proportion of ground surface covered. Within certain limits of rainfall, slope length, and other factors, mulching the entire area gives better protection against water runoff than any other measure of orchard soil management. In addition, a mulch brings about improvement in soil structure and in soil fertility. It keeps the topsoil open, and prevents formation of a crust on the surface. This favors penetration of moisture and air, and thus maintains favorable conditions for both microbiological activities and plant growth. Increases in available potash and organic matter have been found to occur in soil covered for several years with a heavy mulch. The favorable growing conditions existing immediately under a mulch are indicated by the extensive development of small feeder roots often found there. Also, a heavy mulch layer has a stabilizing effect on soil temperature, leveling off the extremes, and thus favors bacterial activity. It makes cultivation around young trees unnecessary (fig. 11, *B*), is particularly effective in preventing competition from weeds on terrace ridges and droughty soils, and prevents bruising of fruit that falls to the ground.

The amount of mulching material used per acre varies considerably according to whether the material is placed around young trees, under the drip of the branches along rows of older trees, in the row middles, or over the entire area. The amount used per acre in the initial application should not fall below about 3 tons, and rarely should it be more than 10 or 12 tons. To be most effective in controlling weeds and conserving moisture, the first application should be about 6 inches deep. After the mulch is well established, additions of from 1 to 4 tons per acre per year will ordinarily be sufficient to maintain the desired depth.

A fruit grower who is starting a mulching program with limited funds or materials obtains better results if he applies mulch in broken, irregularly spaced strips across the slope, at the points where erosion damage is greatest, than if he completely covers a small portion of the orchard site. The sections of the site where soil and water losses are most serious should be given first attention, those less damaged by erosion being mulched later when conditions permit.

There are some hazards in the use of mulch that a fruit grower

should keep in mind. Since mice find favorable conditions beneath a mulch, a well-planned and carefully executed poisoning program for their control is of paramount importance. Some protection from mice can be afforded the trees by keeping the mulch at least 3 or 4 feet from the tree trunks. Particularly in the case of young trees, the mulch should be pulled away from the trunks each fall. Wire guards around the tree trunks, reaching below the surface of the ground, afford a degree of protection against rabbits and some other rodents.

Fire hazard is greatest when a mulch is first applied, and becomes progressively less as the mulch decomposes. For reduction of fire hazard, in some situations it is desirable that alternate tree

FIGURE 11.—*A*, Strip mulching in tree-row middles across the slope restricts water runoff and arrests gully formation; *B*, heavy mulching has eliminated the necessity for cultivating these young peach trees.

rows or middles, or edges of orchard sites bordering potential sources of fire spread such as highways, abandoned fields, or timber stands of highly inflammable types, be left unmulched. Additional fire-protection measures recommended are maintenance of fire lanes and provision of water.

VEGETATIVE GROUND COVER

Plants used for ground covers in orchards should serve at least three functions; they should restrict surface runoff and erosion, maintain or increase the quantity of organic matter in the soil, and improve the soil structure as a contribution to general fertility and tree growth.

FIGURE 12.—The tall hay-type cover crop in this apple orchard would provide a considerable volume of mulch material.

Plants considered for ground-cover use in orchards should (1) be adapted to the local climatic conditions; (2) be capable of growing vigorously under the particular conditions as to soil and shade; (3) be as shallow-rooted as possible, to offer minimum competition to the trees for available moisture; (4) be capable of withstanding orchard travel and reestablishing themselves quickly after being disturbed; (5) be low growing, so that they will not make it difficult to get around in the orchard and will not interfere with air drainage; (6) be fairly easily established by artificial seeding; and (7) make their most rapid growth at the season when it will interfere least with growth of the trees or fruit. In addition, the seed should be commercially available at a reasonable price.

To give maximum soil protection, a cover crop must make dense growth at the ground surface as quickly as possible. The benefits from fertilizing an orchard cover crop have been less appreciated

than those from supplying supplemental nitrogen to the trees. Application of lime, phosphorus, potash, and nitrogen for the cover crop is commonly made apart from application of nitrogen needed specifically by the trees.

Ground-cover plants that are perennial, and so offer continuous soil protection, are usually to be preferred for orchards (fig. 12), especially under irrigation conditions. Their desirability is not limited like that of annual plants by the possibility of seeding failures. Perennial cover plants, to a greater extent than annuals, aid in making the soil more absorptive of water, thus reducing erosion, and improve its structure and increase its content of organic matter, thus making it more fertile. Under many conditions, it is questionable whether the organic content of orchard soil can be maintained economically except under a good sod.

In different sections of the United States, various perennial plants are found that have all or most of the characteristics desired in an orchard ground-cover crop. Grasses thus classified include sheep fescue, red fescue, Canada bluegrass, Kentucky bluegrass, Bermuda grass, redtop, timothy, orchard grass, and quackgrass. White clover and Ladino clover are the best of the perennial low-growing legumes.[4] Alfalfa and sericea lespedeza are sometimes recommended for deep soils where moisture is relatively plentiful.

Grazing of perennial covers by hogs or sheep is sometimes practiced under careful management (fig. 13). This not only controls the height of the crop but furnishes supplementary income to the fruit grower.

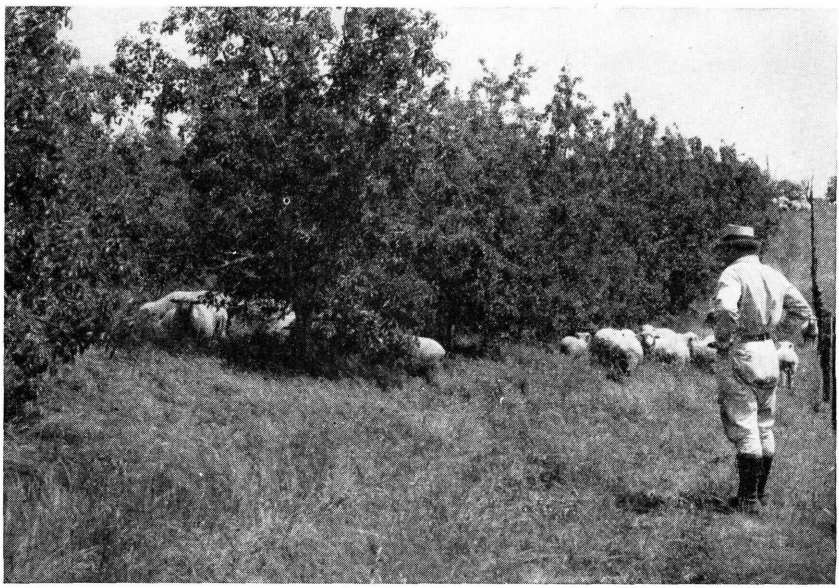


FIGURE 13.—This California pear grower is obtaining the major portion of his fruit-production costs by properly grazing his orchard cover crop.

[4] Biennial sweetclover is an excellent soil builder, but grows too tall if not kept in check by mowing, rolling, or partial cultivation.

Under some conditions, perennial covers are not desirable. They are subject to some objection because of being deep-rooted, strong competitors for subsoil moisture. They also attract some injurious insects such as the buffalo tree hopper.

After a satisfactory perennial ground cover is established, fertilizer should be applied at least every third year in sufficient quantity to maintain desirable plant growth. If legumes form a considerable portion of the mixture, fertilizer needs can usually be met by top dressings with phosphate and occasionally with potash, or, where a complete fertilizer is needed, application of a mixture such as 4–16–4 at a rate of 300 to 400 pounds per acre. If the cover is composed of grasses only, 150 to 200 pounds per acre of ammonium nitrate or its equivalent should be applied in early spring each year until a satisfactory stand is obtained. The acid tolerance of the legumes in the cover-crop mixture determines which soil reaction is most desirable. In general, lime should be applied sufficiently often to maintain a vigorous growth of plant cover and to get the best results from applied fertilizers.

Annual plants are sometimes preferable to perennial plants as ground cover on orchard sites where the zone of tree rooting is restricted and the supply of soil moisture is likely to be inadequate. Annuals are recommended for use on sites of this description where slopes are not too steep or long and soils are not too erodible (figs. 14 and 15). Because cultivation stimulates oxidation or burning out of soil organic matter, the goal in management of annual plant covers should be production of large quantities of plant material to be incorporated into the soil. To achieve this, the same care and attention should be given to seedbed preparation, liming, fertilizing, and seeding as if the crops were being grown for hay or pasture.

Usually, annual cover crops are renewed by artificial seeding each year so long as they are desired. Many of them are not allowed to go to seed, but are disked in before maturity. Annuals that are commonly allowed to mature seed include among others

FIGURE 14.—A dense cover crop of Korean lespedeza is contributing to erosion control on this steep orchard slope.

FIGURE 15.—Within its restricted zone of winter hardiness, bordering the Gulf of Mexico, blue lupine is an excellent winter cover crop for pecan orchards, producing heavy yields of organic matter high in nitrogen.

sweetclover, bur-clover, crimson clover, Alyceclover, crotalaria (fig. 16), and lespedeza. These are classed as reseeding annuals.

Annual cover-crop plants are classified as summer annuals or winter annuals, according to their season of growth. In young orchards or in "off" years, the summer annuals are usually seeded in late spring or early summer. In an orchard having a full crop of fruit, usually the summer cover crop is planted late or is not allowed to make much growth until fruit harvest. Annuals should not be allowed to compete with the trees under summer drought conditions. The plants that make a fairly quick growth after midsummer are most desirable. Soybeans, cowpeas, crotalaria, buckwheat, and certain annual weeds make excellent late-summer growth under favorable conditions. Where shade is not too dense, and soil fertility is high, crabgrass makes a good cover in late summer and furnishes a mat for winter protection.

Reseeding summer annuals, which start from seed in the spring, make their most rapid growth in late summer and then mature, leaving a mulch residue after the first frost. This residue may be left undisturbed until after blossom time or the beginning of cultivation in the spring. The time for spring cultivation and the time of natural reseeding depend on seasonal moisture conditions.

Winter annuals usually are planted in late summer or early fall. They cover the ground during the fall and winter, if moisture and temperature conditions are favorable, but make their greatest growth the following spring. Because of partial seeding failures, resulting in thin stands, this type of cover offers variable protection against winter rains. It may interfere with the trees during

critical periods of the growing season if allowed to grow late in the spring. Among the recommended nonreseeding winter annuals the most widely used legumes are hairy vetch, Austrian Winter peas (*Pisum sativum* var. *arvense*), and Singletary peas (*Lathyrus hirsutus*), and the principal nonlegumes are rye and other small grains. Common reseeding winter annuals recommended for orchard use are crimson clover and bur-clover.

A cover-crop mixture usually consists of one or more legumes and one or more nonlegumes. Rye and vetch form a good standard mixture of this kind. Some other grain may be substituted for rye, and some other legume such as Austrian Winter peas for the vetch. A good summer mixture is soybeans and Sudan grass, with cowpeas as an alternative legume in the far South.

A winter and a summer cover crop may be used in an orchard the same year. In that case, usually one crop is leguminous and the other nonleguminous. Recommended sequences are vetch and crabgrass, rye and soybeans, rye and Korean lespedeza, Austrian Winter peas and Sudan grass.

Many cover crops are being tried in different fruit-producing sections, with varying degrees of success. It is advisable for individual growers to try the different cover-crop species that are thought to be most promising under their soil and climatic conditions until they find the ones that best meet their demands.

TILLAGE

CONTOUR AND STRIP CULTIVATION

Contour tillage is not only a terrace maintenance operation but sometimes a conservation practice in itself. Under some soil conditions, maintenance of a dust mulch reduces soil moisture losses through evaporation. Also, when a row crop is used as an intercrop for a young orchard, the row ridges resulting from cultivation hold considerable quantities of runoff and prevent them from

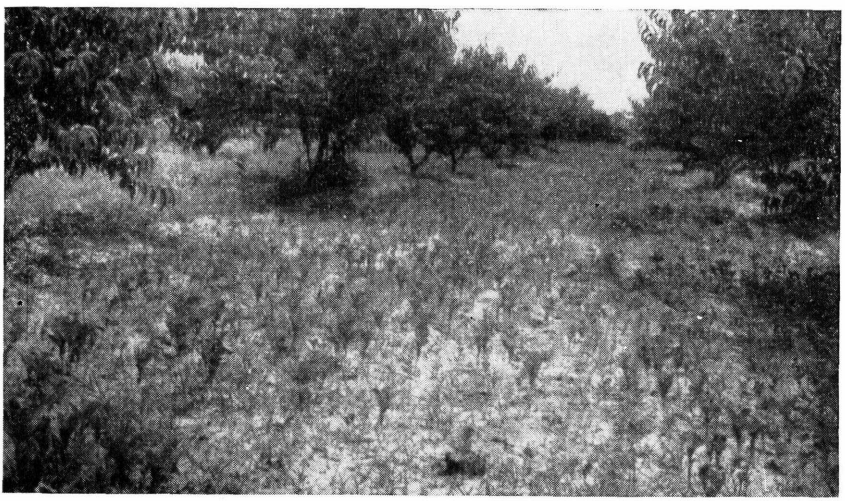


FIGURE 16.—In this orchard *Crotalaria spectabilis* has reestablished itself by natural reseeding despite several spring and early summer cultivations.

reaching the terrace channel. Cotton and low-growing vegetables and small fruits make good orchard intercrops for this reason.

Cultivation in a young orchard need be performed only along the tree rows to the extent of tree-root spread, a soil-improving crop being used on the rest of the area (fig. 17). The band of cultivation should widen as root spread increases, until finally the roots extend to the centers of the row middles. Thereafter the middles can be cultivated and ground-cover plants grown in the tree rows (fig. 18).

FIGURE 17.—Strip cultivation along the tree rows in this young orchard prevents competition for moisture but permits growing a soil-building cover crop in the middles.

FIGURE 18.—Development of these fruit trees to the bearing stage has led to shifting of cultivation to the row middles and use of permanent cover in the tree rows.

In cover-crop management, cultivation has three purposes—to prevent the cover crop from robbing the trees of needed moisture and nitrates, to aid in pest control, and to prevent formation of a crust on the soil. The degree of cultivation should be sufficient only to achieve these purposes. Timeliness of cultivation with reference to rainfall, tree behavior, and pest control is of utmost importance. Under many conditions, mowing of orchard cover crops restricts sufficiently their competition with the trees for moisture.

TRASHY CULTIVATION

Trashy cultivation is the type of tillage that leaves the major portion of crop residues on the soil surface (fig. 19). These resi-

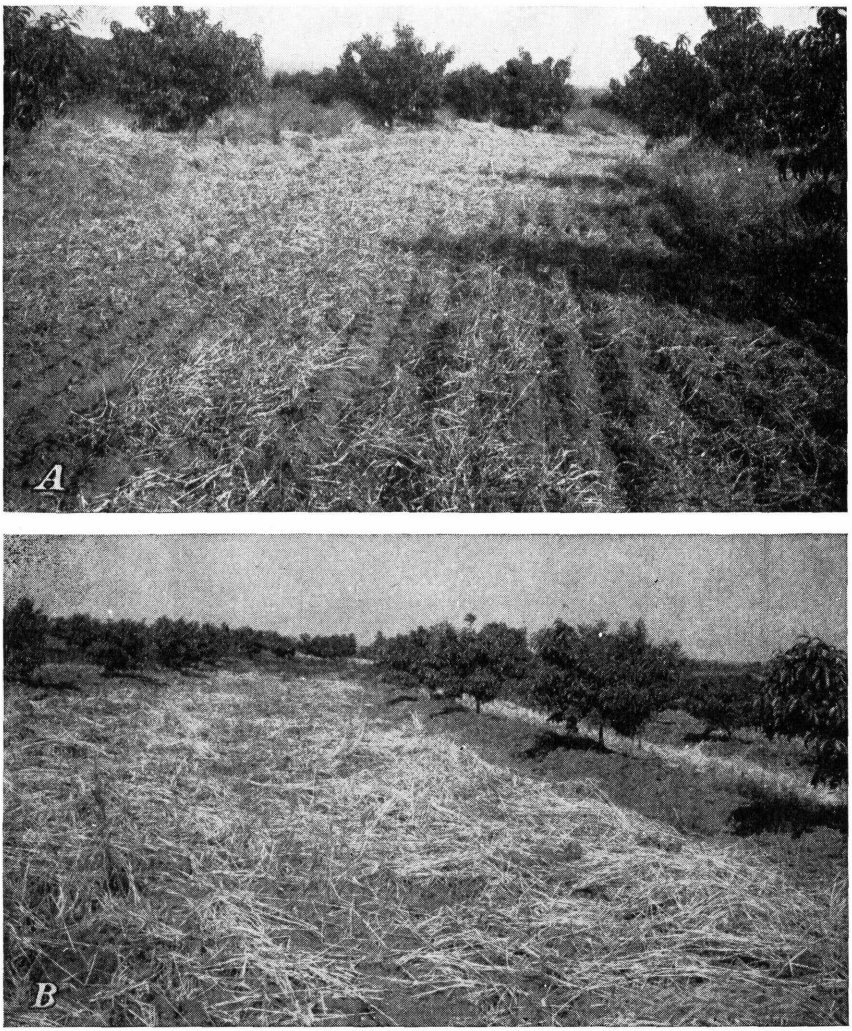


FIGURE 19.—*A*, Residues of crabgrass left on the soil surface after trashy tillage form an effective anchored mulch; *B*, disked rye left as a surface residue conserves soil moisture and does not tie up so much soil nitrate as if it had been turned under.

dues function as a mulch in preventing the formation of a crust at the soil surface, thus allowing much greater penetration of water into the soil. This type of tillage, also, eliminates competition between the cover crop and the trees for soil moisture.

Almost any type of orchard disk harrow or cultivator can be operated in such a manner as to chop a portion of a cover crop into the soil and still leave the major portion lying on the soil surface (fig. 20). Usually the disks can be set at such an angle that they will cut the cover crop down without turning it entirely into the soil. In soils of some types, depth controls are necessary to prevent cutting of tree roots. Sweeps on cultivator shanks work successfully with some cover crops, cutting them off just below the ground surface and leaving all residues on top of the soil. Sweep cultivators do not as a rule operate successfully on rocky soils. Spring-tooth harrows effectively subdue sod covers while leaving much of the residue on top. In the South a cotton-stalk cutter works well in cutting down cover crops of crotalaria and other tall-growing and woody plants.

Where some tillage is considered necessary and burying of all residues is not essential to adequate pest control, every effort should be made to reduce the competition between the cover crop and the trees for moisture but leave a partial mulch cover.

FARM PONDS AND RESERVOIRS[5]

One of the most valuable assets in the complete orchard set-up is a good supply of water. Where this cannot be continuously provided from the outside, a stored supply adjacent to the fruit planting is most desirable. Farm ponds or other reservoirs can occupy land fitted for few other uses. Additional sources of water include small streams (with dams), local springs, and small

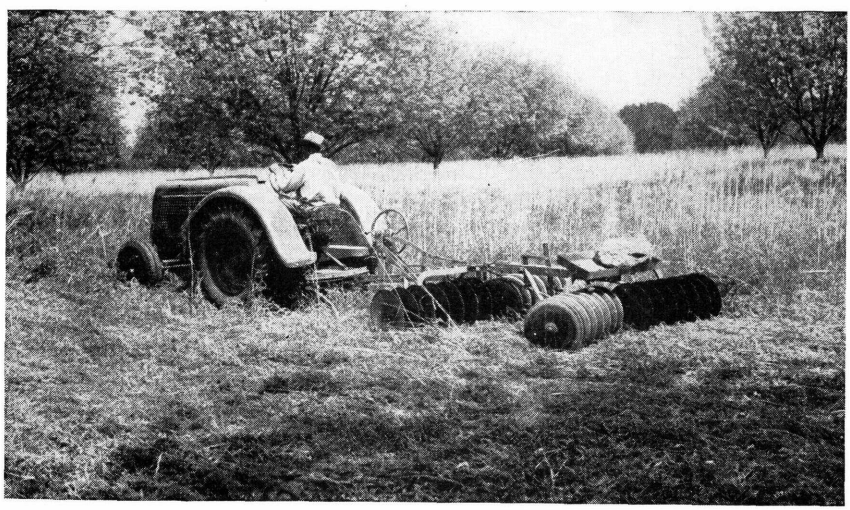


FIGURE 20.—First disking of the vetch and rye cover crop in this pecan orchard is leaving most of the vegetation on the surface.

[5] For detailed information regarding construction of farm ponds and reservoirs, see U. S. Dept. Agr. Farmers' Bul. 1859, Stock-Water Developments: Wells, Springs, and Ponds.

watersheds possibly including the orchard sites themselves. Proper provision should be made for straining the water through screens of vegetation, especially if the water is likely to contain sediment or debris.

Farm ponds have a variety of uses to a fruit grower, of which the greatest is usually for spray water and another is for protec-

FIGURE 21.—*A*, A contour citrus orchard in California that is furrow irrigated in summer, as seen when its soil is protected by a winter cover crop. *B*, Terrace channels in this South Carolina peach orchard serve secondarily as a water-distributing system.

tion against fire. Benefits to wildlife should not be ignored, because birds assist in orchard pest control.

IRRIGATION IN ORCHARD SOIL CONSERVATION[6]

On some orchard sites in sections of the United States where rainfall is scanty or is unfavorably distributed through the year or through the growing season, irrigation contributes to soil conservation. Installed primarily for the purpose of bringing about a soil moisture content adequate for tree growth and fruit production, irrigation has the second effect of making possible the use of a soil-protecting ground cover of perennial plants that otherwise would compete too strongly with the trees (fig. 21, *A*). Even deep-rooting perennial plants can sometimes be maintained through irrigation on an area that otherwise would be without plant ground cover.

A terrace system, if the grade of the terraces is steep enough, can be used successfully to distribute irrigation water (fig. 21, *B*). Where a dense sod or cover crop is present, the grade required for irrigation may be greater than where clean cultivation is commonly practiced. In humid districts where control of flash runoff is the primary purpose of terracing, terraces that are to be used also for irrigation should be designed on the accepted grade for each set of soil and slope conditions involved. Not only terrace channels but contour furrows in the row middles can be used to carry irrigation water.

Sprinkler irrigation of orchards is widely practiced—in avocado plantings on steep slopes in southern California, in citrus orchards on the coarse sands of central Florida, and on many other sites not suitable for terracing. In an orchard where water is applied by sprinkling or by a similar method, it is possible to utilize low-growing ground covers for their benefits in soil conservation. Portable pipes and perforated hose lines also may be used for irrigating sod orchards.

An adequate and economical source of water supply is essential to the practice of irrigation. Whatever water resource meets local conditions best should be developed. Watersheds above ponding areas rarely provide sufficient water for both irrigation and spraying. A natural stream or lake is more dependable.

APPLICATION OF CONSERVATION MEASURES TO NONCONTOUR ORCHARDS

Orchards planted on the square and other straight-lined patterns on sloping lands are subject to varying degrees of runoff and abnormal erosion for the entire life of the planting. Any control measures suggested for application in such orchards are recommended only for temporary use until the trees can be removed, the sites terraced, and new trees planted on the contour. Under some conditions, however, a fairly satisfactory degree of soil and moisture conservation can be obtained in a noncontour orchard

[6] For detailed information regarding irrigation of orchards, see U. S. Dept. Agr. Farmers' Bul. 1518, Orchard Irrigation.

through mechanical measures, such as construction of diversions, plus use of plant covers or mulches.

Diversions should be constructed to carry to a protected outlet any runoff water from adjoining lands, highways, or orchard roads. In an orchard located on a long continuous slope, plant cover alone usually does not give the soil sufficient protection. Under such conditions, diversions should be constructed to break the length of the slope and pick up surplus water for safe conduct from the orchard. Sometimes it is advisable to remove a few trees from an old square-planted orchard to construct a diversion. The number of trees that would need to be removed varies with the age of the planting and the topography of the site and according to whether a staggered or a continuous type of diversion is used. If the trees are large, it may be advisable to use a short outlet to drop the water through the tree row, thus breaking or staggering the diversion slightly, at a point where the diversion would otherwise cross the tree row at a tree location. If the orchard is young, with many years of production still ahead, it may be better to move each tree in a line of diversion construction a few feet closer to an adjacent tree.

Use of diversions, or other adaptable mechanical measures, plus mulching is the best method of soil and moisture conservation in square-planted orchards. The degree of control afforded by mulch in a noncontour orchard depends directly upon the amount applied and its distribution. Complete soil coverage to a depth sufficient to prevent weed and grass growth is most desirable also for soil protection. The next best conservation practice is to use mulch around the trees and keep the row middles in a dense sod. A heavy growth of perennial sod-forming plants is very effective during most periods of the year; but once the water has cut through the sod and starts gullying the subsoil, the sod has lost much of its value. Any degree of cultivation in an orchard leaves

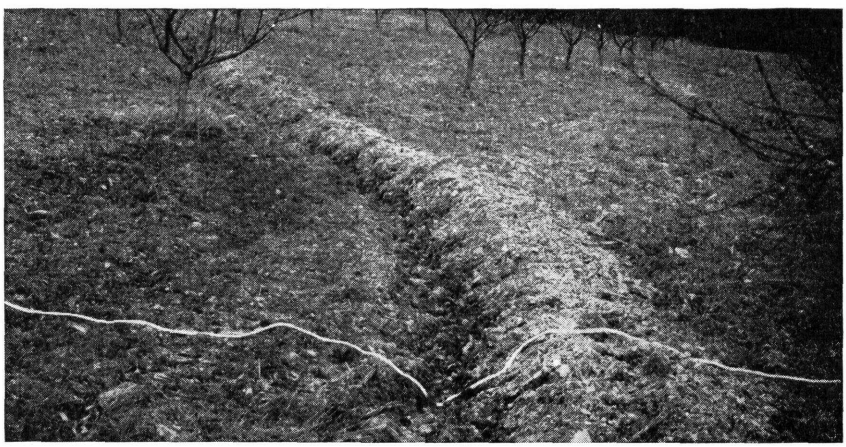


FIGURE 22.—Grade furrows constructed annually after the season of cultivation provide temporary protection during the rainy season when cover-crop protection may be lacking or inadequate.

the land just that much more exposed to erosion. The farther cultivation is off the contour, the greater the erosion hazard. Therefore, any cultivation should be across the slope or as nearly on the contour as the location of the trees permits.

It is extremely important in a cultivated off-contour orchard to maintain a heavy sod in all the natural drainageways, to prevent the unavoidable concentrations of surplus surface water from cutting gullies. Annual furrows laid on grade may be used for partial or temporary prevention of runoff during the annual rainy season or before the winter cover crop becomes established (fig. 22). Trees are usually marked with paint to show the locations of the furrows in case these should become obliterated within the year.

As has been brought out previously, an important feature of establishing and maintaining good cover crops is a suitable fertilizing program.

ADAPTATION OF CONSERVATION PRACTICES TO FRUIT AND NUT SPECIES

Every type of fruit or nut tree and of fruit-bearing vine or bramble grown in the United States benefits from terracing, on sites where otherwise considerable uncontrolled runoff would occur, but individual types differ in their requirements and tolerance with regard to other soil and moisture conservation practices. In general, the types can be grouped in this regard as follows: (1) Apple and pear trees, which require little cultivation; (2) stone-fruit, citrus, and nut trees, which usually require a greater amount of cultivation; (3) vines and brambles, which, although perennial, have tillage requirements similar to those of row crops. The general types of conservation program applicable in relation to each of these three groups will be discussed separately. Exceptions occur in each group, chiefly because of soil influences.

APPLE AND PEAR TREES

Apple and pear trees require little cultivation, especially when grown in deep or heavy soils on sites that have adequate moisture, either naturally or through irrigation. When the trees are young and their root systems are not yet extensive, mulching or hand cultivation is advisable to prevent competition for soil moisture and plant nutrients. After the trees are well established, satisfactory erosion control can be effected by maintaining a ground cover such as a grass sod, provided the slope is not too long (fig. 23).

Under sod culture, the advisability of terracing in apple and pear orchards is determined chiefly by the need for runoff control. Where soil moisture tends to be a limiting factor in either tree growth or fruit production, terracing and contour planting constitute an important means of increasing water absorption and preventing runoff. The terraces also serve as a basic protection if it becomes necessary to destroy the ground cover temporarily.

For apple orchards located on sandy and other droughty sites, the same general treatment given to orchards of stone-fruit and citrus species is desirable.

STONE-FRUIT, CITRUS, AND NUT TREES

Stone-fruit trees, citrus trees, and nut trees, as compared with apple and pear trees, usually require more cultivation or its equivalent, apparently because they are sensitive to shortages in soil moisture and plant nutrients. Until recently it has been com-

FIGURE 23.—Close-growing sod (*A*) and a mixture of hairy vetch and crimson clover (*B*) contribute to erosion control in these apple orchards and also add organic matter to the soil.

monly believed by fruit growers that such a fruit tree as the peach invariably requires a large amount of cultivation in order to grow satisfactorily. The prevailing methods of culture for not only peach but other stone-fruit trees and citrus trees in general include considerable soil tillage, especially at certain times of the year when nitrogen and moisture demands are highest. However, it now appears that continuous cultivation is not always necessary for all these trees. This need is especially questionable if soil-moisture and plant-nutrient requirements are adequately provided (fig. 24).

FIGURE 24.—Under ideal soil and moisture conditions a low-growing, shallow-rooted sod cover has proved satisfactory for erosion control in this apple and peach orchard without sacrifice of heavy fruit production.

In the case of pecan orchards, spring and summer tillage is not only essential to optimum tree growth and nut production but definitely helpful in insect and disease control. Late-summer or early-fall tillage serves as a method of conserving available soil moisture for filling the nuts. With edible-nut trees and tung trees, tillage should usually precede the harvest period, making the ground fairly bare to permit economical gathering. In some instances, the winter cover crop is planted before the harvest operation begins and is disked in the following spring.

The peach has traditionally been cultivated as much as any fruit tree in existence. There seems to be some justification for this. In common with the other stone-fruit trees, peach trees have two definite periods of fruit development within which soil-moisture shortages are particularly detrimental. The first occurs between petal fall and pit hardening and lasts a month or longer,

varying in length among the different varieties. At this same time the tree makes its greatest twig growth, and therefore utilizes a large portion of the available winter reserve of soil moisture, which may or may not be replaced by current rainfall. If a fast-growing cover crop is in competition with the tree at this period it robs the tree of both moisture and nitrates, with the result that the tree's growth is curtailed and its foliage turns yellow. A heavy application of mulch at this time may produce the same effects unless supplemental nitrogen is applied. The second period is that of rapid fruit enlargement, the 3- to 5-week period preceding fruit harvest. At this stage depletion of soil moisture is more damaging than shortage of nitrates, and is much more feared by the fruit grower. To prevent any possible competition with the ripening fruit, summer cover crops should be planted as late as possible before fruit harvest.

Where ground-cover plants cannot be used to the extent of giving adequate erosion control, more reliance must be placed on terracing and other mechanical practices. This means contour planting of most orchards on sloping lands and also terraces of the type best adapted to the climate and to functional needs. Moisture conservation is often of primary importance for trees of this group, and under some conditions irrigation is required even in humid sections. Once an adequate terrace system is functioning, the fruit grower has a wide choice of supplemental means of conserving soil and moisture. Under most conditions, a well-balanced program consisting of a water-disposal system combined with use of ground-cover crops or mulches should be adopted for soil and moisture conservation, in which all phases of good soil management are considered (fig. 25).

GRAPEVINES AND BRAMBLES

In both vineyards and bramble plantings, good soil-management practices constitute a considerable portion of the erosion-control program. However, the longer life cycle of grapevines prevents the usual type of crop rotation on vineyard sites. With these two types of small fruits there is closer spacing of rows, so that contour ridging plays a greater part than terracing in connection with contour planting. Seeding a suitable summer cover crop as soon as possible after the last cultivation is a logical practice. In the case of some cane fruits like the raspberry, mulching of row middles is economically feasible.

Vineyards on steep slopes present an especially serious erosion problem, because the life of grapevines is longer than that of such fruit trees as peaches. Tillage up and down the slope leads to serious erosion in many vineyards. Because of such tillage in the past, good grape sites in favored districts are becoming extremely scarce. A decided change of planting methods is necessary in areas where the damage is most extensive.

Contour planting has proved highly successful in commercial grape culture. The steepness of many of the slopes used for commercial vineyards makes bench terraces essential to such a layout. In a bench-terraced vineyard cultivation is confined to the flatter area above each row. The riser below the row is best kept under a low but permanent plant cover. Trellises constructed on

FIGURE 25.—Peach trees on top of plow-built contour ridge between terraces, where they have excellent growing conditions. The heavy summer cover crop will be converted into a mulch residue.

the contour are proving stable. Trellis posts should be set closer and deeper at locations of sharpest curves than where rows are comparatively straight (fig. 26).

ASSISTANCE THROUGH SOIL CONSERVATION DISTRICTS

In order to establish certain soil and moisture conservation measures, the fruit or nut grower needs technical, on-site guidance. Practical on-site assistance in such measures from a Gov-

FIGURE 26.—Contour planting and ridging, supplemented by a good cover-crop program, have resulted in adequate control of soil erosion on this sloping vineyard site.

ernment technician is now available to all fruit and nut growers whose orchards lie within areas that have been organized as soil conservation districts, through cooperative action of farmers. Usually, assistance in installing soil and moisture conservation measures begins with a conservation survey of the farm. This survey shows, field by field, the kinds of soil, the extent to which erosion has already injured the site, the percent of slope, the present land use, and the capability of the land to produce. Assistance is available to the cooperator in so laying out his orchard that planting and all subsequent cultural and other operational work can be done on the contour. A conservation plan for the orchard is then worked out by the grower and the conservationist. It contains practical recommendations for erosion control, moisture conservation, irrigation (if applicable), improvement in land use, and soil management on each block of the entire orchard acreage. The area to be planted is usually diagrammed (fig. 27). The resulting plan of planting, together with a conservation map of the other parts of the farm, gives the grower a clear picture of the total conservation needs of his orchard.

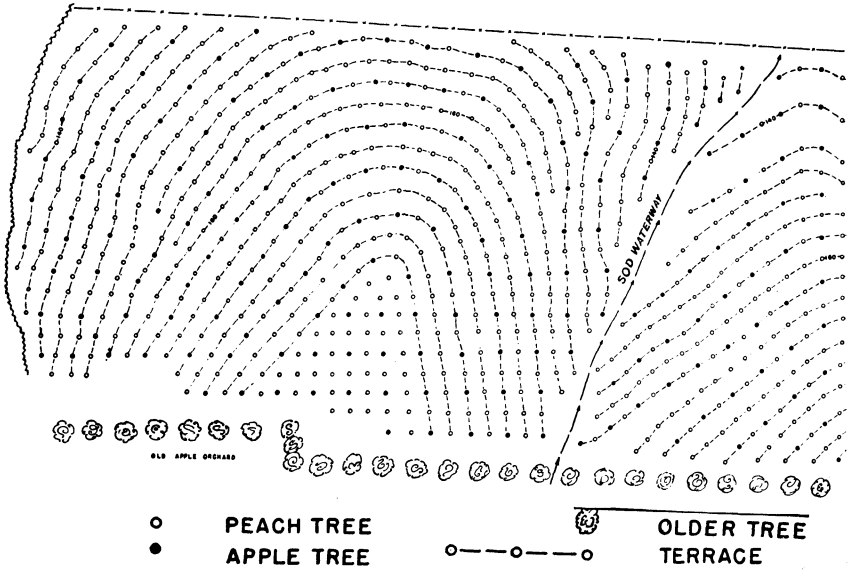


FIGURE 27.—Contour-planting diagram for 9-acre apple orchard with peach trees interplanted.

Under some conditions the conservation needs of an orchard call for equipment not immediately available to the grower, such as machinery for terracing, leveling land, or installing an irrigation system. Use of such equipment is now being supplied by many soil conservation districts at reasonable cost to the fruit grower.

Cooperative assistance to the individual fruit grower, including technical assistance from the United States Department of Agriculture, through organization of soil conservation districts is now provided for by law in 45 States.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1945—643464